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AUTHOR Stodolsky, David: And Others
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ABSTRACT

The validity of an automated experimental system incorporating a computer mediator for resolving conflicting requests to speak among four-member problem-solving teams was assessed. Learning how to use problem-solving strategies was affected by this new method for facilitating participation in dialogue. Strategy learning among shy and assertive groups was mediated by a computer-executed rule resolving conflicting requests to speak in favor of those having spoken least. Total time waiting for one's turn to speak and the rate of rejection were shown to be related to initial shyness level and also to vary over the course of three problem-solving games. A discriminant function analysis identified the set of variables which accounted for most of the variance in assignment of subjects to the four treatment conditions which were based upon scores on the Personal Report of Communication Apprehension. Analysis of variance was performed to detect shyness level by game interactions. (Author)

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Automatic Facilitation of Dialogue in Shy and Not Shy Problem-Solving Teams*

David Stodolsky**
University of Louisville

Larry Bascom
Philip G. Zimbardo
Stanford University

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**Correspondence address:
David Stodolsky, Ph.D.
Systems Science Institute
University of Louisville
Louisville, Kentucky 40208

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The purpose of this study was to assess the validity of a computer-based experimental system incorporating an automatic mediator for resolving conflicting requests-to-speak in four person problem-solving teams. Measures of interaction and problem-solving derived from the experimental data were correlated with scores on the Personal Report of Communication Apprehension (PRCA) (McCroskey, 1970), a measure of shyness. Groups differing in their mean shyness levels used an Equal-time resolution rule during conferences in which they discussed strategies for solving a permutation and combination problem presented by the computer. The Equal-time rule always resolved conflicting requests to speak in favor of the person who had spoken the least thus far, by displaying the new speaker's name on television screens which could be seen by each visually isolated member of the team. Participants submitted requests to speak by pressing and holding a button near their microphones. The independent and anonymous channel for requests was expected to yield data predictive of individual personality characteristics. This protected mode of expression permitted simultaneous inputs from all participants and thus a higher data rate then could be derived from the analysis of speaking patterns alone.

The experimental system and an automated system for processing the resulting data had previously been demonstrated in a study comparing two different resolution rules (Stodolsky, 1976). There the Equal-time resolution rule was compared to a first-come, first-served (First-in, First-out) rule often used in large meetings. In that experiment, groups were selected from participants who had been ranked by communication apprehension (PRCA) scores so as to maximize within group heterogeneity and between group homogeneity. Thus each shyness level was represented equally in each group. In the present study all members of a group were drawn from a given quartile in the stratification. The homogeneous nature of the group was expected to magnify tendencies of persons with a certain shyness level to interact in a characteristic manner. The intent was to validate the experimental system and specifically the automatic mediation procedure as a diagnostic instrument. Stodolsky (1978) reviewed group research with electronic response and data collection systems applicable to clinical decision-making and group problem-solving. Various rules for facilitating therapeutic, learning, and performance oriented groups were discussed in detail in that review.

Method

Subjects

Fifty-two male undergraduates were recruited from the Stanford University introductory psychology subject pool (Fall, 1978). They were selected on the basis of their communication apprehension scores (PRCA, McCroskey, 1970) which were obtained several weeks prior to the experiment. This measure was part of the administration of a battery of questionnaires given to all 250 students in the introductory psychology course. Four quartiles were formed based on the ranking of each class member on the PRCA. From these quartiles, four types of groups were composed. They varied in their level of shyness across conditions, but were relatively homogeneous within each condition.

The group composition procedure thus involved selecting 4-man teams on the basis of the quartiles of the communication apprehension scores. From the persons in the most assertive quartile, one group would be formed with the first, tenth, twentieth and thirtieth persons in the ranking. A second highly assertive group consisted of the second, eleventh, twenty-first, and thirty-first persons in the ranking. Four such 4-man groups were formed within each of the quartiles from highly assertive, moderately assertive, moderately shy and highly shy individuals. (When this exact procedure could not be followed due to conflicts in scheduling, the nearest available person in the quartile ranking was substituted).

Due to machine malfunction, scheduling difficulites and some subjects failing to appear on time, it was not possible to complete the design. Table 1 indicates the size and characteristics of the groups actually studied.

Procedure

Subjects were called prior to the experiment and were told what the experiment was about, what the compensation was, and when to arrive (Appendix A).

Table 1

Groups by Shyness Level

	Group Name	Group Number	Number of Participants
HIGHLY SHY (HI-SHY)	ES3	G13	4
	ES4	G14	4
	ES5	G15	4
	ES8	G18	4
MODERATELY SHY (MOD-SHY)	ES6	G26	4
	ES7	G27	4
	ES9	G29	3
MODERATELY ASSERTIVE (MOD-ASS.)	EA5	G35	4
	EA6	G36	4
	EA8**	G38	4
HIGHLY ASSERTIVE (HI-ASS.)	EA1	G41	3
	EA3*	G43	4
	EA4	G44	3
	EA9*	G49	3

Note: Most efficient Problem Solvers N = 52

** Prize winners

* Tied for second place

Upon arrival at the experimental room, they were required to wait until all members of their team appeared, or until five minutes after the scheduled starting time if three were present. They were then seated and given verbal instructions (Appendix B). At the completion of these, they read additional instruction reminders (Appendix C) placed at each conferencing position and then indicated by depressing their switches their readiness to continue. Additional information was then presented by the computer (Appendix D).

Each team competed for a prize of $20.00 per participant, based upon maximal use by each person of clues given during problem-solving. Because individual guesses had to be entered before discussion of the latest clues took place, interchange of information on the strategy of clue utilization was most valuable. A suggestion as to a specific guess could be outdated by the set of clues subsequently presented by the computer. Both the small number of participants on each team and the payoff for group performance tend to maximize co-operation and minimize the need for automatic conflict resolution. The design therefore was a severe test of our general research strategy.

Differences in problem-solving and in patterns of intra-group communication during conferencing phases of problem-solving tasks were studied as a function of level of group shyness-assertiveness under the equal-time (EQTM) resolution rule. In equal-time conferencing, the mediator selected the person waiting who had spoken the least time thus far.

The problem-solving and interaction measures (Variable List)

The task was a logic problem in which the goal was to correctly select and order four out of six objects. It was patterned after a popular game called Mastermind, marketed by Invicta Plastics Limited. The game proceeded by alternation of clues presented by the computer and participant guesses. Each of the guesses consisted of four choices from a set of colors. Four different

colors had to be chosen, or an input error was indicated by a message, and the participant had to choose again. The clues were a preset sequence of guesses with associated feedback. The preset sequence was the independent guess of a "robot." Thus each group was exposed to an identical set of clues, even if their own guesses were markedly different. The game consisted of four guesses, with feedback indicating the number of correct colors selected and the number of colors placed in the correct location.

The robot demonstrated an optimal strategy, that is, one which used all information in previous clues. The individual guesses were objectively scored with reference to this same criterion by a protocol analysis program. The program scored both inconsistency in choice of colors and inconsistency in ordering the colors chosen. A minimum of inconsistency indicated effective strategy learning.

To minimize talking among team members without using their speaker request switches, an experimental assistant monitored each group and enforced the rules of the system. He also kept a log of any subject behaviors of potential interest. The duration of each session averaged about 80 minutes (ranging from 60 minutes to 90 minutes). At the end of each session he and a senior experimenter debriefed the subjects thoroughly and paid them for their participation. The $80.00 prize to the most efficient problem-solving team was given at the end of the experiment. All team scores were made available to interested participants.

Results and Discussion

The initial data analyses were based on individual and group scores on our series of communication and problem-solving variables. Individual shyness scores on the communication apprehension scale were not utilized (due to some temporary problems). Instead, the shyness group assignment which had been based on these individual scores was the predicted criterion. After protocol analysis of the

Table 2

Group counts

	Group 1 SUBFILE HIS	Group 2 SUBFILE LOS	Group 3 SUBFILE LOA	Group 4 SUBFILE HIA	Total
Count (N)	16.0000	11.0000	12.0000	13.0000	52.0000

Means

	Group 1 SUBFILE HIS	Group 2 SUBFILE LOS	Group 3 SUBFILE LOA	Group 4 SUBFILE HIA	Total
LG1SCORE	4.1250	4.1818	4.6667	5.0000	4.4808
LG2SCORE	3.7500	3.6364	3.6667	4.2308	3.8269
LG3SCORE	4.0625	3.9091	4.8333	5.0000	4.5192
CG1SCORE	5.0625	4.0909	5.0000	4.8462	4.7885
CG2SCORE	5.4375	5.3636	5.5000	5.0000	5.3269
CG3SCORE	5.2500	4.9091	5.5833	5.5385	5.3269
LOCCON	12.1875	11.7273	13.1667	14.2308	12.8269
COLCON	15.7500	14.3636	16.0833	15.3846	15.4423
LOCPAY	8.0625	7.5455	8.5000	9.2308	8.3462
COLPAY	10.6875	10.2727	11.0833	10.5385	10.6538
CONS	27.9375	26.0909	29.2500	29.6154	28.2692
PAY	18.7500	17.8182	19.5833	19.7692	19.0000
READS	367.9969	-790.5064	721.5850	497.0515	632.7733
REQG1	2.4375	4.0909	7.3333	8.6154	5.4615
REQG2	2.0000	10.9091	5.9167	10.2308	6.8462
REQG3	2.7500	9.1818	3.5000	3.7692	4.5385
SELG1	2.1250	3.0000	5.9167	7.6923	4.5769
SELG2	1.6875	8.4545	4.8333	8.3846	5.5192
SELG3	2.4375	7.4545	3.0833	2.9231	3.7692
WAITG1	2.0681	4.7864	6.7067	13.1800	6.4915
WAITG2	2.6906	16.3136	8.0817	12.9254	9.3752
WAITG3	2.5519	19.8091	3.3150	5.2977	7.1112
PREG1	0.3125	0.3636	1.2500	0.6154	0.6154
PREG2	0.2500	0.1818	0.1667	0.4615	0.2692
PREG3	0.3750	0.2727	0.1667	0.1538	0.2500
MISG1	0.6875	0.2727	0.5833	1.3077	0.7308
MISG2	0.1875	0.2727	0.4167	0.5385	0.3462
MISG3	0.3125	0.4545	0.0833	0.5385	0.3462
ELAPG1	17.5806	28.2773	28.0867	66.0469	34.3844
ELAPG2	15.7656	74.7782	37.9517	75.8254	48.3863
ELAPG3	21.5056	64.1764	24.0375	22.2460	31.3702
REJECT1	-0.0625	-0.0909	0.2500	-0.1538	-0.0192
REJECT2	0.0000	0.0000	0.5667	0.0000	0.1538
REJECT3	0.0000	0.0000	0.4167	0.4615	0.2115
REJECT4	0.1250	0.0000	0.1667	0.3077	0.1538
REJECT5	0.1875	1.0909	0.1667	0.1538	0.3654
REJECT6	0.3125	0.4545	0.3333	0.3077	0.3462
REJECT7	0.0000	0.5455	0.6667	0.3846	0.3654
REJECT8	0.0000	0.1818	0.1667	0.6154	0.2308
REJECT9	0.0000	1.2727	-0.0833	0.5385	0.3846
REJECT10	0.0625	0.7273	-0.0833	0.2308	0.2115
REJECT11	0.2500	0.0000	0.0000	0.0769	0.0962
REJECT12	-0.0625	0.0000	0.2500	0.0769	0.0577
REJECT13	0.0625	1.0000	0.2500	0.4615	0.4038
REJG1	0.3125	1.0909	1.4167	0.9231	0.8846
REJG2	0.3125	2.4545	1.0833	1.8462	1.3269
REJG3	0.3125	1.7273	0.4167	0.8462	0.7692
REQTOT	7.1875	24.1818	16.7500	22.6154	16.8462
SELTOT	6.2500	18.9091	13.8333	19.0000	13.8654
WAITTOT	7.3106	40.9091	18.0000	31.4001	22.9779
PRETOT	0.9375	0.8182	1.5833	1.2308	1.1346
MISTOT	1.1875	1.0000	1.0833	2.3846	1.4231
REJTOT	0.9375	5.2727	2.9167	3.6154	2.9808
TOTELAP	34.8669	167.2659	90.4050	164.1567	114.1673
STD1G1	31.6769	26.2045	23.7023	23.2015	26.5802
STD1G2	98.1475	70.2418	68.2750	67.6500	79.4037
STD1G3	109.5906	94.3027	73.1533	106.1503	97.0948
STD1G4	53.1100	67.7391	70.4067	67.5900	66.9046
STD2G1	28.7056	36.2055	28.0692	43.4477	34.0154
STD2G2	73.1650	66.9402	64.0500	70.5577	69.0946
STD2G3	130.8713	153.9073	134.0667	120.6192	140.5340
STD2G4	124.3775	144.6564	100.1573	133.9877	128.6190
STD3G1	28.7081	22.4627	27.7533	23.3246	25.8208
STD3G2	65.4244	74.0235	67.6650	46.5205	63.2063
STD3G3		137.3027	114.0385	155.7377	141.5996

raw data, aggregate data from each conference period (1-13), summary data for each game, and totals for the entire experiment (Table 2) were passed to the SPSS Discriminant analysis program (Nie, Hull, Jenkins, Steinbrenner & Bent, 1975). These variables were used to predict the estimated shyness level of each participant.

Our empirical findings support the theoretical orientation on which this research was based: shyness is a significant subject variable which affects communication processes in small groups and is implicated in modifying group problem-solving efficiency. We may also conclude that it is possible to discriminate with accuracy differences in four levels of shyness (between problem-solving teams) on the basis of the communication variables we have isolated for molecular analysis. We will here examine a set of the variables which were most significant in predicting shyness level.

When a person desires to speak to other members of his group, he first depresses his switch, then waits for his name to appear on the display. This waiting time might be short if no one else wants to talk, or if the person has a high priority to talk (as a function of the particular request-conflict resolution rule in effect). On the other hand, time can be long when other group members also desire to talk, have requested a turn and the given team member's turn has a relatively low priority. The TOTAL WAITING TIME DURING CONFERENCING is the variable (WAITTOT). Our research reveals it is the best single predictor of shyness level ($p < .001$). Waiting time during game on (WAITGI) was also highly significant ($p < .001$), even considering the variance already accounted for by total waiting time. This waiting time variable alone accounts for over 40% of the variance in shyness.

A more detailed treatment of the waiting time measure through analysis of variance with repeated measures (BMD P2V) (Shyness X Game X Guess) confirmed

Table 3

ANOVA for waiting time to talk

ANALYSIS OF VARIANCE FOR 1-ST DEPENDENT VARIABLE - T1G1 T1G2 T1G3 T1G4 G1 T2G2 T2G3 T2G4 T3G2 T3G3 T3G4

SOURCE	SUM OF SQUARES	DEGREES OF FREEDOM	MEAN SQUARE	F	PROB. F EXCEEDED
MEAN	2540.48645	1	2540.48645	118.15208	0.000
S	717.73889	3	239.24630	11.12679	0.000
ERROR	1032.08804	48	21.50183		
T	75.68697	2	37.84348	2.55949	0.083
TS	446.92581	6	74.48764	5.03787	0.000
ERROR	1419.41075	96	14.78553		
G	308.91206	3	102.97069	8.19281	0.000
GS	577.66701	9	64.18522	5.10687	0.000
ERROR	1809.65222	144	12.56842		
TG	293.53409	6	48.92235	4.37765	0.000
TGS	265.92966	18	14.77387	1.32199	0.172
ERROR	3218.54153	288	11.17549		

the significance level of the main effect ($p < .001$, (Dixon & Brown, 1977). As suggested by the discriminant function analysis, the interaction between shyness and game was also significant ($p < .001$). The analysis of variance also detected a highly significant interaction between guess and shyness level ($p < .001$). In addition to variation accounted for by shyness, the waiting time variable was also significant across guesses ($p < .001$) and in the game by guess interaction ($p < .001$). See Table 3 for ANOVA table that shows significant effect.

In general, this pattern of findings means that waiting time is a powerful measure of both individual and task characteristics. This variable permits us to account for most of the variation in shyness level as assessed by the Personal Report of Communication Apprehension. In light of the limited discussion which took place in this pilot study,we can conclude that it is an extremely sensitive measure for assessment of individual differences.

The effects of both game and guess task characteristics were also accounted for by the waiting time variable. This guess effect suggests that changes in task complexity are reflected in this variable. The game by guess interaction suggests that the waiting time variable is sensitive to strategy learning manifested as the session proceeds. The interactions between individual and task characteristic (shyness x game, shyness x guess) indicates the variable is sensitive to aptitude-treatment interactions. Virtually every aspect of the experimental paradigm is reflected in the waiting time measure.

Of special interest to us is the waiting time behavior of the subjects in the moderately shy groups. Over the three games their pattern of responding deviates dramatically from that of all other groups. In Figure 1 mean waiting time by game is plotted for each of the four experimental groups. During Game 1 waiting time is a direct reflection of initial level of shyness, with the highly assertive subjects choosing to wait longest for their turn to speak, the highly

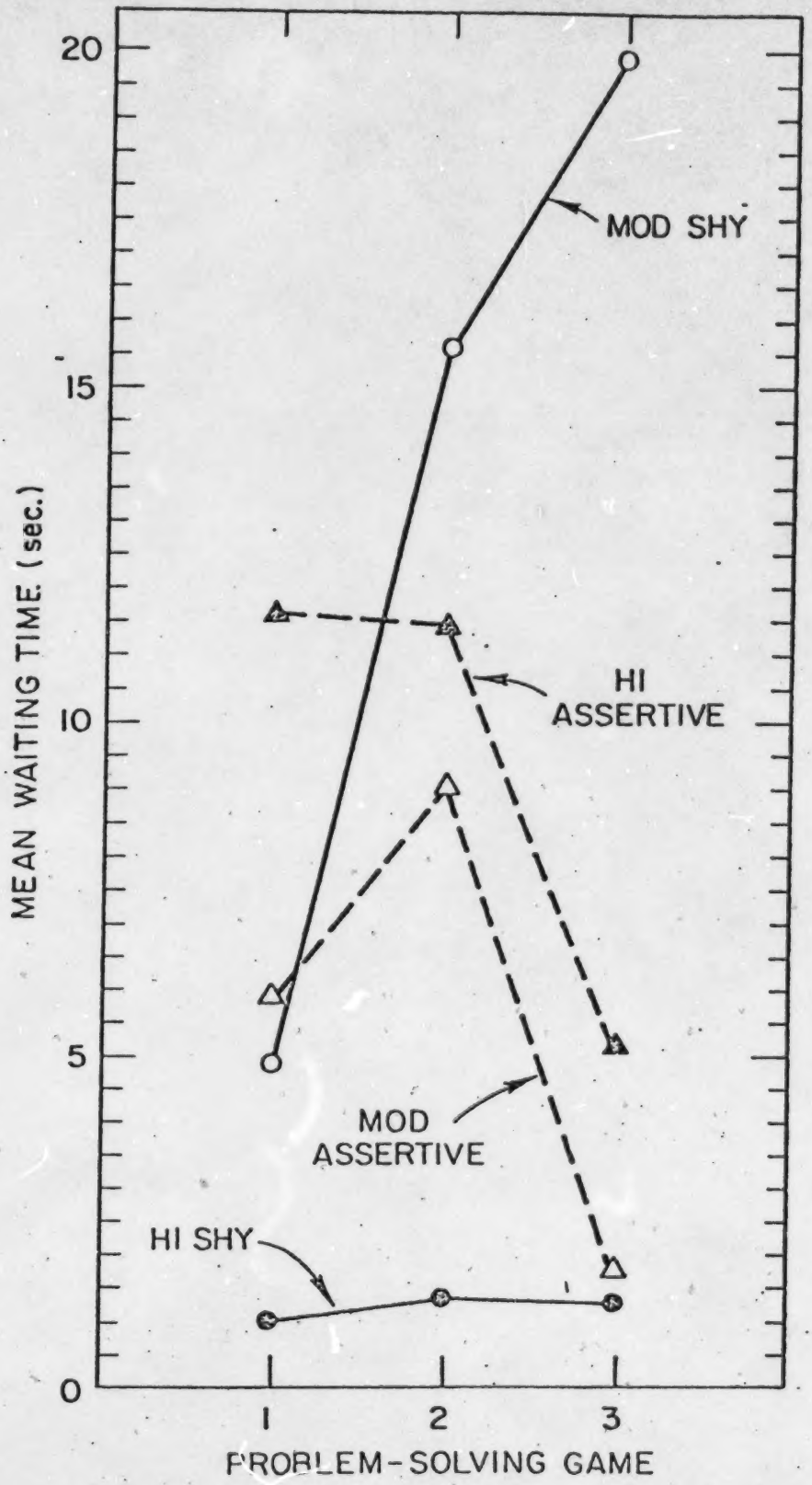

Figure 1 - Mean waiting time (to talk) in each of three successive problem-solving games as a function of shyness level.

shy waiting least (barely at all), and the moderates, assertive and shy, appropriately in between these extremes. Over games this relative position is maintained, though diminished in absolute size, for the highly assertive, moderately assertive and highly shy groups. As can be seen in the figure, there is little change by the extremely shy over games, but considerably less willingness to wait to talk evidenced by the assertive groups. In contrast to this general pattern stands the behavior of the moderately shy. They continue to increase the time they are willing to wait from game to game until by the last game, they are waiting four times as long as the most assertive groups. The psychological processes that contribute to such variations in waiting time are complex, but can be disentangled by the methodology we have designed.

Expections about the efficacy of waiting will also influence waiting time. People who expect a fair opportunity to have their say, should wait longer than those who expect others to dominate and control the available talking time. Thus chronic differences in willingness to wait one's turn to talk should be affected by specific situational variables, group norms, task considerations and the operation of equity considerations in a dyad or group setting.

Waiting time should also be a function of anticipated pay off, that is, the imagined consequences of having taken one's turn. If one anticipates positive outcomes, in terms of social reinforcement, progress toward task solution, increased sense of self-efficacy, or material rewards (bonuses, promotions) for satisfactory participation, then waiting time will be greater than under anticipation of negative outcomes.

However, during the period of time when one is waiting his turn to communicate, another psychological process may be stimulated. Anticipatory anxiety--in the form of excessive self-conscious monitoring of one's thoughts, worry about the value of one's contribution, concern about inadequate or inappropriate

responding--can depress memory (Brenner, 1976; Hatvany & Zimbardo, 1978). In our present problem-solving task such memory interference will be detrimental to utilizing efficient solution strategies.

In this experiment, the first game was constructed to be substantially easier than the last two. If we consider the effect of anticipatory anxiety on problem-solving, the optimal strategy would be to reduce waiting time as the experiment proceeded. As task complexity goes up, waiting time should go down.

During a given game each set of clues increases the processing load of the tasks, since clues form overlapping sets which specify the set of correct responses. Problem-solving appears to be in correspondence with waiting time. The moderately shy group with its inappropriate waiting pattern (see Figure 1) scored worst on both the location (LOCCON) and color (COLCON) consistency measures of problem-solving. In contrast, the highest consistency scores are found in the highly assertive groups (see Table 2).

A comparison of total elapsed speaking time (TOTELAP) and total waiting time (WAITTOT) over the entire session indicates the moderately shy come to talk as much as the highly assertive group, but they wait longer to talk.

Thus these preliminary cross-sectional data analyses suggest that treatment of communication apprehension will involve more than merely increased participation. Our Equal-time conferencing rule did dramatically increase the level of participation of the moderately shy individual. But it did not improve problem-solving effectiveness. To the contrary, the desire to talk more, leading to longer waiting times may have generated anticipatory anxiety which worked against optimal utilization of clues in problem-solution. The moderately shy person appears to be the ideal candidate for shyness treatment since he/she can be readily induced to increase participation using our game strategy and computer-mediated conferencing paradigm. However, we will have to assess the anticipatory

anxiety of such individuals (using on-line physiological measures) and then attempt to intervene to help the person gain control over this nonproductive arousal before appropriate participation and effective assertion in a problem-solving team are achieved. A fundamental assumption of our research program, based upon automatic mediation, is that the independent channel for requests to speak can facilitate coordination by resolving speaker-order conflicts. "Such a full-duplex communication systems permits the development of more finely grained algorithm for group problem-solving . . ." (Stodolsky, 1978, p. 145). The significance levels of the waiting time variables found in this pilot study illustrates the value of the independent channel for requests in experimental investigation. The utility of the research program is strongly supported since this variable cannot be measured at all without an independent channel for requests. What remains to be demonstrated is that the information transmitted on this channel can be effectively utilized in group facilitation.

The second major set of highly significant ($p < .001$) variables were rejections within individual conferences. It is the number of times a person requested to speak but did not receive a turn. This measure is derived from two variables, requests and selects. Each time a participant pressed his switch in order to speak, and kept his request pending until the previous speaker finished his turn, he was scored one request. Each time a person's name appeared on the screen (he received a turn), he was scored one select. Rejections during a particular conference (e.g., REJECT2 in conference two) is the result of subtracting selections from request (REQUEST2-SELECT2)*.

Rejects were found to be highly significant by both shyness grouping ($p< .001$) and in the interaction of shyness and guess. Again the moderately shy group

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*This varible may be contaminated by turns in which a person spoke beyond the 20 second time limit, but was not interrupted by others, thus he would be selected twice (for two turns) based upon a single request. This problem will be corrected in the final analysis.

reveals a unique behavioral pattern in evidencing most rejections on the latter guesses of any group, and on an increasing number of them relative to the steady low level of all other groups. This unusual pattern of rejection suggests an interaction process which actually maximizes rejection when task preformance is most likely to be disrupted by it. Analysis of variance detected interaction with shyness grouping on other variables, requests (three interactions, in each p beyond .001), selects (three interactions, in each p beyond .001) and elapsed time (three interactions $p < .001$, $p < .001$, $p < .005$).

Significance levels given above, however, must be interpreted with caution since individual subject analyses were applied to a group experiment. Thus, within and between group variance is not separated, as is appropriate for a hierarchical design. When these errors are corrected and actual, as opposed to estimated, communication apprehension scores are used for analysis, the results can be excepted as definitive. The highly significant patterns of results in these preliminary analyses suggest further data analysis would be productive.

Summary

Some general conclusions are:

1. Stodolsky's (1976) automatic mediation paradigm offers an effective way to study processes operating at a molecular level during a group problem-solving session. It allows us to study the operation of ten (10) communication-process variables singly or in combination.
2. The automated protocol analysis procedures (developed to handle this complex data string) insured that only well-formed data strings, those free of error from machine malfunctions, were processed for statistical analysis.
3. Automatic mediation of speaker selection was shown to influence participation rates of individual team members and to clearly alter the group dynamics of teams composed of moderately shy members (but not of those very shy).
4. Shyness as measured by the Personal Report of Communication Apprehension (PRCA) was shown to be a valid predictor of behavioral differences in patterns of interaction across groups. These dispositional or habitual effects of shyness were clearest on the first problem-solving game, but were modified over subsequent games as a consequence of situational forces induced by task demands, group conferencing experiences, the equal-time rule, and perceived problem-solving effectiveness.
5. In teams composed entirely of extremely shy members participation was <u>not</u> enhanced by the Equal-time resolution rule since conferencing was minimal and rarely was there a need to resolve a conflict in requests to speak.

6. The participation made possible by the automatic mediation system's Equal-time resolution rule was dramatically demonstrated within moderately shy teams. On a number of communication measures they were initially about as unresponsive as their more extremely shy peers. But the intervention of an automatic mediator had the effect of their surpassing (on some measures) even the teams with all highly assertive members by the final problem-solving game. But there are other lines of evidence that suggest they might have felt more anticipatory anxiety as a consequence of their longer waiting-to-talk time.

Thus this preliminary research offers hope that our approach may indeed have therapeutic implications for modifying the communication and problem-solving behavior of some types of individuals who characteristically are low participators.

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Appendix A

Phone Introduction

--This is Larry Bascon.

--I am Phil Zimbardo's research assistant over in the Psychology Department.

--We are running a experiment in group problem solving--in which a group of four persons attempt to solve a series of problems.

--It is a two hour experiment. Participants receive one hour of experiment credit for Psychology 1 and $3.00 for the second hour of involvement.

--In addition there is a special $80 bonus for the group in the experiment that does the best in the problem solving. That is $20 per person for that group.

--If you are available I would like to arrange a time when you could participate in this experiment.

--Please understand that when I sign you up you become a member of a four-person group and it is very important that you can make it and be on time. If for any reason you are unable to make it would you please call 497-2097 and leave a message. The experiment will take place in Jordon Hall Room 331.

Appendix B

Verbal Instructions

--(Take names and subject cards.)

--(Type in number of participants and names.)

--(Seat subjects.)

--This is an experiment in group problem-solving.

--You four are now a group: and as a group you will attempt to solve a series of problems.

--All instructions and information for the color quiz game will be given to you by the computer on these screens, but I have a few introductory instructions.

--A Martian Robot will go through the color quiz game with you and demonstrate an optimal solution strategy. You will use his guesses and the feedback he receives as clues to develop your own solution strategy.

--You as a group will discuss the problems, share ideas about possible solution strategies and then each of you individually will make a guess. Each of you will be scored on your guesses, and from those your group will recieve a cumulative score, therefore, it is important to help each other out if you hope to win the prize, but you will receive no feedback on your individual guesses.

--During the initial instruction period you may talk freely.

--But once we start the game you must talk only during conference periods. They are indicated on the screen: "Equal time conference, waiting for next speaker." During conference periods you must request to speak from an automated parliamentarian. You do so by pressing your button. Keep pressing when talking.

--The automated parliamentarian will display your name on the screen when it is your turn to speak.

--Remember to speak only during conference periods and when your name appears on the screen. Points are deducted for speaking at the wrong time.

--All further instructions will be given to you by the computer.

--Please put on the earphones and test them by saying your name.

--(Ask each subject if he heard all the names.)

--Read the instruction reminders on the desk in front of you and then look up on the screen for further instructions.

Appendix C

Color Quiz

Instruction reminders
Read and refer to in case of difficulty.

The experimental assistant's job is to record if people speak when their name is not on the screen. He has no other role except to enter your names on the computer terminal at the beginning of the experiment. He will answer all questions at the end of the experiment.

Guesses: If the computer complains about your choice, it may have been due to an erroneous input. This may force you to change your original guess.

Your first round guess will test your powers of precognition. However, after each guess, you will get a clue, which is a robot's guess and feedback. The robot follows an optimal strategy; try to predict its guess. The feedback displayed on the screen is in response to the robot's guess. Three clues should permit you to determine the correct answer.

Instructions: During the instruction period at the beginning of the experiment you can speak as you wish.

Conferences: During all other conference times, however, only one person can talk at a time. If you talk and your name is not on the screen your group will be penalized one point. You also lose one point when you miss using a clue. You are unlikely to win the prize if you or others in your group talk out of turn repeatedly. Therefore, if you want to speak to the group, be sure to depress your switch and keep it depressed until your name appears; continue holding it down until you have finished. When you press your switch to speak, the automated parliamentarian puts your name on a list. When the present speaker finishes, one of the people holding their switch down is selected. The list if examined to find the person who has spoken the least so far. If you are selected, your name will appear on the screen. Conferencing terminates when no one requests to speak for 10 seconds.

Appendix D

WELCOME----> YOU SHOULD HAVE
A PEN AND THREE WORK SHEETS ON YOUR TABLE. PRINT YOUR
NAME ON EACH WORK SHEET AND NUMBER THEM FROM 1 TO 3.
THESE SHEETS ARE PROVIDED TO ASSIST YOU IN SOLVING
EACH PROBLEM.
PLEASE HOLD YOUR KEYSET
WITH YOUR LEFT HAND SO THAT YOU CAN WRITE WITH YOUR
RIGHT HAND ON THE WORK SHEET(IF RIGHT HANDED).
WHEN THE KEYSET IS HELD IN THE LEFT HAND
YOUR BUTTON CAN BE EASILY DEPRESSED WITH YOUR THUMB.
THIS IS THE ONLY BUTTON USED IN THIS EXPERIMENT.
IT IS A SPECIAL TYPE OF BUTTON WHICH DOES NOT MOVE
MUCH WHEN PRESSED. IT DOES TRIGGER AN INPUT TO THE
COMPUTER. A FIRM PRESSURE FOR A HALF OF A SECOND IS
SUFFICIENT TO INDICATE YOUR RESPONSE. THE BOTTOM ROW
OF NUMBERS INDICATES WHICH PERSON IS READY. WHEN YOU
PRESS YOUR SWITCH ONE OF THE NUMBERS WILL CHANGE FROM
0 TO 1 INDICATING YOU'RE READY TO GO ON. NOW PRESS YOUR SWITCH.

WELCOME TO THE 'COLOR QUIZ' GAME.

THE OBJECT OF THE GAME IS TO SELECT AND ORDER
FOUR DIFFERENTLY COLORED PEGS.
THE PEGS ARE PLACED IN ORIFICES 1 THROUGH 4.
EACH ORIFICE RESPONDS TO ITS CORRECT COLOR.
A DIFFERENT COLOR IS TO BE PLACED IN EACH ORIFICE.

THE OPTIMAL GUESSING STRATEGY WILL BE DEMONSTRATED BY
A SIMULATED ROBOT.

AFTER YOU GUESS A SEQUENCE,
THE ROBOT WILL GUESS A SEQUENCE AND RECEIVE THE APPROPRIATE
FEEDBACK. THEN THE ROBOT WILL REPORT THE RESULTS TO YOU.
----------> PRESS YOUR THUMB SWITCH.

THERE ARE SIX CHOICES,
EACH OF THEM IS A DIFFERENT COLOR:
R = RED Y = YELLOW G = GREEN
B = BLUE V = VIOLET O = ORANGE
BUT ONLY 4 OF THEM ARE CORRECT.

IF AN ACTIVE COLOR IS SELECTED, IT WILL BE
INDICATED AS A RIGHT "COLOR". IF CORRECTLY PLACED,
IT WILL ALSO BE INDICATED AS A RIGHT "ORIFICE".
ONLY WHEN 4 "ORIFICE"S OCCUR AT ONCE WILL THE GAME END.

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YOUR TASK IS TO GUESS THE CORRECT SEQUENCE OF COLORED
PEGS TO BE INSERTED. THE ROBOT WILL PERFORM THE OPERATIONS
AND REPORT BACK THE NUMBER OF "COLOR"S AND THE NUMBER
OF "ORIFICE" RESPONSES ON EACH ATTEMPT.

IF EACH PERSON IN YOUR GROUP LEARNS HOW TO SOLVE THE PROBLEM WITH THE MINIMUM NUMBER OF TRIES, YOUR GROUP IS LIKELY TO WIN THE PRIZE!
IT IS NOT SUFFICIENT FOR YOUR GROUP TO SOLVE THE PROBLEM WELL, EACH PERSON MUST BE ABLE TO DO IT! IF YOU SHARE YOUR IDEAS ABOUT PROBLEM-SOLVING STRATEGIES, IT MAY HELP YOUR GROUP TO WIN THE PRIZE.

YOU WILL BE ASSISTED IN YOUR DELIBERATIONS BY OUR AUTOMATED PARLIAMENTARIAN. YOU CAN NOTIFY THE MACHINE THAT YOU WISH TO SPEAK BY PRESSING YOUR THUMB SWITCH. THE MACHINE WILL DISPLAY THE NAME OF THE PERSON WHO HAS HAD THE LEAST TIME SO FAR. WHEN YOU HAVE A QUESTION OR COMMENT PRESS DOWN AND HOLD YOU THUMB SWITCH UNTIL YOUR NAME APPEARS. IT WILL BE YOUR TURN TO TALK. WHEN YOU RELEASE YOUR SWITCH, THE NEXT PERSON'S TURN WILL START.

THE SEQUENCE OF EVENTS IN THE GAME--

0. GET AQUAINTED CONVERSATION. NAME CLAIMING.

1. GUESS FOUR DIFFERENT COLORS WHICH INDICATE THE ORDER OF PEGS TO BE INSERTED.

2. THE COMPUTER WILL DISPLAY EACH PERSON'S GUESS

3. A DISCUSSION OF THE CHOICES WILL CONTINUE UNTIL TIME RUNS OUT OR NO ONE REQUESTS TO SPEAK FOR 10 SECONDS.

4. GUESS FOUR DIFFERENT COLORS.

5. THE FEEDBACK "COLOR"S AND "ORIFICE"S WILL BE DISPLAYED.

6. START GUESSING SEQUENCE AGAIN.

SUMMARY

HOLD YOUR KEYSET IN YOUR LEFT HAND.

PRESS FIRMLY ON YOUR THUMB SWITCH TO RESPOND

THE ROBOT WILL REPORT:

:"COLOR"S --NUMBER OF ACTIVE PEGS SELECTED

:"ORIFICE"--NUMBER OF PEGS PLACED IN CORRECT ORIFICE.

REQUEST TO SPEAK BY PRESSING AND HOLDING YOUR SWITCH-

-SPEAK WHEN YOUR NAME APPEARS

-RELEASE YOUR SWITCH WHEN THROUGH.